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AS A MYCOPHAGIST

BY

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## THE RED SQUIRREL OF NORTH AMERICA AS A MYCOPHAGIST.

By Professor A. H. R. Buller, D.Sc., Ph.D., F.R.S.C.

In the Transactions of the British Mycological Society for 1916, an interesting paper was published by Hastings and Mottram upon the edibility of fungi for rodents. It was shown by citations from other authors, by field observations, and by a series of experiments that both squirrels and rabbits attack the fruit-bodies of many of the higher fungi and devour them as food\*. The investigations of Hastings and Mottram were made in England but their conclusion that squirrels and rabbits are mycophagists doubtless applies not merely to British species but very generally to non-British species the world over. As a contribution to our knowledge of the relations of rodent and fungi I shall here record a series of observations upon the Red Squirrel and its fungus food, made by myself and by several other naturalists in Canada and the United States.

The Red Squirrel or Chickaree has an extensive geographical range in North America, for it is found in the woods of Canada and the United States from the east coast to the Rocky Mountains. It does not hibernate profoundly during the winter for, on any sunny winter's day, it may be seen about the trees in woods. I myself have seen it in mid-winter at Winnipeg in a park and about houses. The Red Squirrel feeds on the seeds of fir-cones, nuts, etc., but it is also an habitual mycophagist. In the autumn, it often collects fleshy fungi in large numbers for its winter supply of food and it stores the fungi sometimes in holes and sometimes on the branches of trees. This latter mode of storage, although of peculiar interest, does not seem to be generally known to mycologists even in North America.

Whilst studying fungi in the woods at Gimli on the western shore of Lake Winnipeg, at Minaki on the Winnipeg River, and at Kenora on the Lake of the Woods, I have many times observed fruit-bodies of Hymenomycetes which had been partly devoured or otherwise injured by rodents. From the appearance of the damaged fungi which was similar to that described by Hastings and Mottram, I came to the conclusion that the destructive agent was sometimes a squirrel and sometimes a rabbit.

\* S. Hastings and J. C. Mottram, The Edibility of Fungi for Rodents, Trans. Brit. Mycolog. Soc., Vol. v, 1916, pp. 364-378.

In the autumn of 1919, I spent many days studying the fungi in the woods about Kenora. There, in the first week of October, *Armillaria mellea*—the Honey Fungus—was exceedingly common, and I noticed that, here and there, clumps of it had been damaged by a rodent. I also found a few isolated, half-eaten fruit-bodies hanging in the forks of branches of trees at a height of from six to about twelve feet above the ground. Two of these fruit-bodies I identified as *Armillaria mellea* and one as *Hygrophorus chrysodon*. I suspected that the destructive agent had been a Red Squirrel, for Red Squirrels were not uncommon in the woods. On October 6, my suspicions were confirmed. On that day I was approaching the Lake of the Woods and, just as I came to its margin, I saw a Red Squirrel on the top of a wood-pile close by the water's edge not twenty feet away. I stood still and observed that the squirrel was sitting on its hind legs with its tail curled over its back and was engaged in eating an agaric held in its fore-paws. I watched this little scene for some moments and then drew nearer, whereupon the squirrel suddenly dropped the fungus and darted away. I then went up to the wood-pile and recovered the fungus which proved to be a fruit-body of *Armillaria mellea*. The pileus had been eaten all around the periphery; but the disc showed the characteristic honey colour and scales, and the stipe still retained its annulus and its peculiar dingy yellow base. On the ground at the foot of the wood-pile I found a clump of *Armillaria mellea* fruit-bodies, some of which had been broken off by a rodent. Doubtless, this clump had been the source of the fruit-body which the squirrel had been eating.

Dr W. P. Fraser, Plant Pathologist of the Dominion Division of Botany, made the following statements to me: "In some of the woods in Pictou County, Nova Scotia, Red Squirrels are very numerous. Many scores of times I have seen these animals carrying or eating the sporophores of Hymenomycetes. A squirrel, after seizing a sporophore upon the ground and before eating it, usually carried it to the top of a stump or log or up to one of the branches of a tree. Partially devoured sporophores were often left lying about on stumps, logs, etc. Most of the fungi were Russulæ."

Dr E. M. Gilbert of the Botanical Department of the University of Wisconsin told me that in the woods of Wisconsin he had often watched squirrels picking fungi, running with them along the ground, carrying them up trees, and eating them on the branches. When making these observations, he usually lay on the ground with his head resting on a cushion. Among the fungi carried up into the trees were various species of *Russula* and also *Lactarius piperatus* parasitised by *Hypomyces lactifluorum*.

It thus appears that the Red Squirrel is just as keen a mycophagist in the State of Wisconsin as in Nova Scotia more than a thousand miles distant.

Professor J. E. Howitt of the Ontario Agricultural College told me that at Muskoka, Ontario, in the month of September, he had often seen squirrels carrying fungi about trees, and that once he had seen an *Amanita* so carried. Sometimes the squirrels fetched and carried fungi with great persistency for several days in succession. Doubtless they were laying up provender for the winter.

The Red Squirrel stores up fruit-bodies of fungi for the winter often in large quantities. Sometimes the fruit-bodies are: (1) stored in bulk in a hole in a tree, in an old crow's nest or in some disused building, etc., but sometimes they are (2) hung up separately in the horizontal forks of trees. When thus hung up in the autumn, they soon dry and thus become preserved until the snow is on the ground and they are required for food.

(1) *Storage in bulk.* Mr Stuart Criddle of Treesbank, Manitoba, in a letter to the author, says: "I have often found fungi stored by squirrels above ground but never under ground. The chief places where I have found fungus stores have been wood-peckers' holes, hollow trees, and birds' nests—especially crows' nests." Soon after writing thus, Mr Criddle very kindly sent me a collection of dried fungi which had been stored by a squirrel in an old box in the loft of a disused house. In the collection there were 116 fruit-bodies altogether, many still quite intact, but some partially devoured and some represented only by large fragments. Of these 116 fruit-bodies, 22 were Boleti and 94 Agaricaceae. The former weighed  $6\frac{1}{4}$  oz. and the latter 14 oz., so that the total weight was 1 lb.  $4\frac{1}{4}$  oz. The fruit-bodies were sent to me in February and, owing to this being a very dry time of the year, they were exceedingly dry and very tough or brittle. When being gathered by the squirrel, they must have weighed many pounds. Some of the pilei bore the characteristic marks of a squirrel's incisor teeth. Many of the Boleti, and perhaps all, belonged to *Boletus scaber* and, among the Agaricaceae, there were at least two species of *Russula*, at least one species of *Cortinarius*, a *Hypholoma*—possibly *H. fasciculare*, and *Lactarius piperatus*. Some of the fruit-bodies of the last-named species had been parasitised by *Hypomyces lactifluorum* and therefore showed only slight ridges beneath their pilei in place of gills. A second collection of fungi sent me by Mr Stuart Criddle from another squirrel's home at Treesbank was even larger than the first for it contained between two and three hundred fruit-bodies. These, except in their

larger number, resembled the fruit-bodies of the first collection, so that a further description of them is unnecessary.

Mr Norman Criddle of the Dominion Department of Agriculture, has informed me by letter that he has never yet found fungi mixed with the usual winter stores of squirrels but that, nevertheless, he has found "old holes in trees literally crowded with semi-dry fungi which had apparently been stored as they were gathered and not previously dried." He further states that the fungus stores were invariably abandoned so that he could never trace the owner. These stores resembled those already described and may well have been collected by the Red Squirrel.

Dr C. N. Bell of Winnipeg has a summer-house at Minaki, a village situated where the Canadian National Railway crosses the Winnipeg River, 114 miles east of Winnipeg. This house, after having been closed for the winter in the autumn of 1916, was invaded by squirrels. The squirrels stored cones and fungi in the attic and made two nests in the mattresses on the beds. The number of stored-up fungi was large. Dr Bell wrote to me concerning the invasion of his house as follows:

"On opening my summer-house on the shore of Sandy Lake in the village of Minaki in the spring of 1917, I found unmistakable evidence that one or more of the Common Red Squirrels which play about the rocks and trees of the locality, had obtained access to the house, for there were two squirrels' nests in the mattresses on the beds and, in the attic, many gnawed pine-cones and a large quantity, say two or three quarts, of dried fungi. Also, many dried stalks of fungi were scattered about the other parts of the house accessible from the attic. Some individual squirrels have become so tame that they run up the steps to the veranda floor and, holding on to the wire screening, peer in on us while we sit at meals; and, occasionally, they have eaten crumbs out of my little daughter's hand. At times they are rather a nuisance as they frequently jump from the trees to the roof of the house and scamper about in the very early morning, at the same time making their chattering noise. Closing up every crevice in the roof and attic has effectually prevented them from entering the house since 1917."

The above observations made by Messrs Stuart Criddle and C. N. Bell prove conclusively that the Red Squirrel does store fleshy fungi in bulk in the autumn for winter use. The air in Manitoba during the autumn and winter is very much drier than in England, so that the collected agarics dry without rotting or becoming unduly mouldy.

(2) *Storage in the forked branches of trees.* When I first heard of squirrels storing fungi in the branches of trees, the story

sounded in my ears like a romance and I was somewhat sceptical. However, as a result of a series of enquiries, although I myself have not as yet seen a tree with more than two fungi hanging in it, I cannot now doubt that trees laden with fungi by squirrels have been observed by others. Thompson Seton writes of them quite familiarly and his observations are supported by others made by M. W. Gorman in Alaska and by my personal friends and acquaintances at Winnipeg.

Thompson Seton in his well-known book on the mammals of North America writes of the Red Squirrel as follows:

"The second food supply in winter is mushrooms, chiefly of the genus *Russula*. If these were to be stored in the same way as the other provisions they would doubtless rot before they could be of service. The Squirrel stores them in the only available way, that is, in the forked branches of the trees. Here they are safe from the snow that would bury them, from the Deer and Field-mouse that would steal them, and instead of rotting, they dry up and remain in good order until needed."

"I have seen Red Squirrels storing up these mushrooms in the Sandhills south of Chaska Lake, Manitoba, in the Selkirk Mountains, on the Ottawa, and on the upper Yellowstone River. The Squirrel's sense of private ownership in a mushroom-stored tree is not so clear as its feeling regarding a hoard of nuts it has gathered.

"During early winter in Manitoba I have once or twice seen a Red-squirrel dig down through the snow to some mushroom still standing where it grew, and there make a meal of it.

"While camped at Caughnawanna, on September 14th, 1905, I was witness of a comic display of frugality and temper on the part of a Red-squirrel. A heavy footfall on the leaves had held me still to listen. Then appeared a Chickaree labouring hard to drag an enormous mushroom. Presently it caught in a branch, and the savage jerk he gave to free it resulted in the 'handle' coming off. The Squirrel chattered and scolded, then seized the disc, but again had the misfortune to break it, and now exploded in wrathful sputterings. Eventually, however, he went off with the largest piece and came back for the fragments one by one.

"The scene was an exact reproduction of one described by Dr Merriam in 1884."

Thompson Seton evidently thinks that the tree-fork mode of storage is the only kind of storage for fungi resorted to by the Red Squirrel, but in this he is in error for, as I have shown by citing the observations of Stuart Criddle and C. N. Bell, the Red Squirrel often stores up fungi in bulk in various holes and cavities. I suspect, but am not sure, that bulk-storage in holes

and cavities is more common than storage in the branches of trees.

M. W. Gorman who has botanised in Alaska, is reported by W. A. Murrill as having made the following statement\*:

"In the region west of the Yukon River the small red or 'pine' squirrel lives during the winter upon the seeds of *Picea alba* and mushrooms. The latter are collected in large quantities during the summer and placed in the forks of branches and other secure spots above the ground to dry." Three different kinds of brownish-coloured agarics were noticed by Gorman who says that the squirrels visit their collections every day, even in the coldest weather.

The two following statements sent to me in writing by Mr Ernest Hiebert and Mrs Doern, both of whom are known to me as careful observers, supplement one another and prove in the clearest manner that, in Manitoba, the Red Squirrel not only stores fungi in particular trees in the autumn but also feeds upon the fungi so stored during the winter.

Mr Ernest Hiebert thus recounts his observations:

"In the middle of August, 1917, at Sandy Hook, near Gimli, Manitoba, I noticed what appeared to be a mushroom stuck between the lower branches of a spruce tree. Upon closer examination I discovered several more fungi in the same tree to the number of twelve in all. Most of them were in the lower branches about fifteen feet from the ground and a few as high as forty feet from the ground. They had all been placed between the horizontal forks of the twigs in the upright position in which they grow. I removed several of these fungi and found them quite dry and all apparently belonging to the genus *Russula* except one, which I took to be *Lactarius piperatus*.

"Several days later in the same grove of spruce trees, I came across a Common Red Squirrel carrying a fungus along the ground. Upon being pursued, it dropped the fungus which proved to be a perfectly fresh *Russula*."

Mrs A. H. Doern's observations were made in a suburb of Winnipeg and are still more interesting. She says:

"In October, 1918, I noticed a common red squirrel carrying a mushroom up one of the trees which grew in my yard at Norwood. The fungus was then placed between the twigs so that the gills looked downwards. Several more mushrooms were placed in a similar position in the same tree; and, during the winter that followed, I repeatedly watched the squirrel eat of these dried mushrooms. The squirrel would remove a mushroom from the twigs on which it had rested, nibble at it, and then replace it as before but in some other part of the tree.

\* W. A. Murrill, Animal Mycophagists, *Torreya*, Vol. II, 1902, pp. 25-26.

Finally, during a cold spell in mid-winter, the mushrooms which still remained all disappeared from the tree and, after this, the squirrel failed to return."

Another observer who has watched squirrels taking fungi up into trees and storing them there is my friend and colleague, Dr Gordon Bell, who writes as follows:

"I have often seen squirrels carrying pieces of fungi up into trees. At Fox Lake in Ontario there was a large pinkish fungus which was very common in the woods and which interested me because I wished to find out whether or not it was edible. One day in the latter part of August, for fully fifteen minutes, I watched a red squirrel carry pieces of the fungus up into a pitch-pine tree and deposit them in the forks made by the branches. I have also seen squirrels in Fort Rouge, Winnipeg, carrying pieces of a Peziza-like fungus up into trees. I think it highly probable that the squirrels eat these fungi after they have dried, but I cannot assert this from actual observation."

From the foregoing evidence, it appears that the storing of fungi in the branches of trees in the autumn by the Red Squirrel is a well developed instinct. It is remarkable with what care the fungi are deposited. The fork of a branch is first selected and then the stipe is pushed downwards through it so that the pileus rests on the twigs, the result being that the fruit-body as a whole cannot fall to the ground by its own weight or be easily dislodged by the wind or by the swaying of the branches. The trees chosen by the squirrels for their open larders are usually Spruce-trees.

In England, during the late autumn and winter, as is well known, the climate is mild, the rainfall heavy, and the periods of frost not very intense or long continued. The English squirrel lays up for the winter a store of nuts and seeds but, so far as is known, never any fungi. Fleshy fungi, if stored by this animal either in holes or on the branches of trees would, owing to the dampness and mildness of the English climate, surely be apt to go rotten rather rapidly. On the other hand, in the inland parts of Canada and of the northern United States, the climate, during the late autumn and winter, is relatively very cold, the precipitation relatively slight and in the form of snow, and the frost very severe and prolonged. In central and western Canada and in North Dakota, snow lies upon the ground and the earth is frost-bound for at least four months each year. In the northern part of North America, therefore, the storage of winter food-supplies by squirrels is even more important than in England. The Red Squirrel lays up for the winter not merely cones and nuts but, in addition, a store of fungi. Owing to the dryness and coldness of the climate, the fungi hung in the branches of

trees by squirrels in late autumn, dry without rotting and remain good to eat until the spring comes, while those deposited in bulk in holes, although moist when collected, become partially dried and, in this condition, preserved by the action of the frost. The fungi heaped together in holes, etc., are put by the weather into a state of cold storage resembling that in which mankind now preserves many of his food-stuffs, such as beef and mutton. The storage of fungi for the winter, by increasing and varying the supply of food, is undoubtedly beneficial to the Red Squirrel and is due to an instinct which appears to have been developed in response to severe winter conditions.

Mr J. B. Wallis, Principal of the Machray School, Winnipeg, once observed a squirrel which, instead of storing fungi in the branches of a tree, hung up there two chickens. As is well known, the Red Squirrel robs birds' nests and kills birds freely. The killing of the two chickens, therefore, was not very extraordinary; but the hanging of the chickens in the forked branches of a tree was a very curious and unusual proceeding and suggests that for once the fungus-storing instinct had become perverted. Mr Wallis has written to me concerning the incident as follows:

"A red squirrel had taken up its abode just behind a farmhouse near Thornhill, a village some eighty miles W.S.W. of Winnipeg. This squirrel had become quite friendly and showed no fear of its human neighbours. One day, whilst visiting the house, I was called outside and here was the squirrel laboriously dragging by the neck, up a small oak-tree, a chicken nearly as big as itself. On looking more closely, two other chickens were discovered, hung by their heads in forked branches. The three chickens had all been killed by bites at the back of the head. The squirrel, on perceiving my friend and myself, immediately seemed to sense disapproval of his thrifty habits and retired rapidly to a high bough from whence he was dislodged with a charge of number six shot. As a really advanced squirrel, he thus fell a victim to his very advancement."

*Summary.* The Red Squirrel of North America not only feeds on the seeds of fir-cones, hazel-nuts, etc., but is also an habitual mycophagist. In the late autumn, it often collects fleshy fungi in large numbers for its winter supply of food, and it stores these fungi sometimes *en masse* in holes in tree trunks, old birds' nests, etc., and sometimes separately on the branches of certain trees.



